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Acoustically effective nonwoven material for vehicle liners

The present invention relates to an acoustically effective nonwoven material according to the preamble of Claim 1.

Nonwovens are increasingly utilized by the automobile industry because of their advantageous acoustic properties. In particular, it is the aim of the automobile industry to utilize liners which, depending upon their usage, have differing acoustic properties, are lightweight, are relatively thin, are easily formable but still stable and in addition are easily recyclable. It is therefore desirable to benefit from liners which fulfil a number of technical functions at the same time whilst minimizing the costs for expensive materials.

Known liner parts as are disclosed, for example, in publications Nos. US-2001/0036788 or EP-0'939'007, all have composite structures with a plurality of discrete layers, each of these layers fulfilling a different technical function.

It has proven to be disadvantageous that the manufacture of such composite structures is relatively complicated because different material layers must be prefabricated and subsequently adhesed to each other. Furthermore, these composite structures have the tendency to become delaminated with time. The effort required to counteract this delamination with the aid of adhesive foils and/or dots is relatively large and makes the manufacturing process more expensive.

It is therefore the aim of the present invention to provide an acoustically effective nonwoven for lining motor vehicles which does not have the disadvantages of the known parts. In particular it is the aim of the present invention to provide a porous nonwoven which has enhanced and easily adjustable sound absorption and form stability properties. At the same time this nonwoven should be lightweight and thin, should be durable and easily recyclable.

This aim is met by the present invention by providing a nonwoven having the features of Claim 1, and in particular by providing an acoustically effective nonwoven having a predetermined air flow resistance and form stability, consisting of a fibrous skeleton comprising support or coarse fibers, into which skeleton microfibers are introduced, whereby at least a portion of these microfibers are completely melted on. This ensures that the nonwoven is stiffened in its surface region, which extends over half of the thickness and preferably over one third of the thickness of the fibrous nonwoven and that it has a predetermined air flow resistance. Thus, the different required technical functions of the

inventive nonwoven are achieved by introducing microfibers of the same or of differing types into the surface region of a preselected fibrous skeleton. Therefore, the inventive liner does not comprise discrete layers but has a continuously changing weight quota of microfibrous material introduced into the fibrous skeleton.

The present invention uses a well known manufacturing process such as is described, for example, in DE-100'44'694. This publication discloses the manufacture of a nonwoven such as is used for soft and tensile wiping towels. This manufacturing process provides for joining a layer of spunbonded fibers to another layer of meltblown fibers by means of a hydrodynamic entanglement process.

Additionally, EP-0'418'493 discloses a two-layer nonwoven for use as panty liners or disposable nappies whose individual layers are joined to each other by directing fine jets of water on to a particular layer in such a manner as to partially transport the fibers from this directly hit layer into the other layer, thereby creating a tear-resistant bond between the two layers.

Nonwoven fabrics manufactured in this manner are usually used for products in the field of personal or household hygiene and, as a rule, are not particularly suitable for use as stable, i.e. self supporting motor vehicle liners or as acoustically efficient motor vehicle parts. In particular, in these known nonwovens the fine fibers are evenly distributed through the entire fibrous skeleton (moist wipes) or are merely twisted together at the mutual surfaces of the discrete layers (cleaning towels).

In contrast thereto and according to the present invention, all microfibers are completely transported into the surface region, i.e. into less than half of the thickness of a fibrous skeleton consisting of coarse fibers. The depth of this surface region is determined by the penetration depth of the microfibers and hereinbelow is defined by the statistically average penetration depth. Statistically, the weight quota of the microfibrous material in the surface region changes continuously, i.e. decreases constantly with depth.

Thus, manufacture of such a nonwoven occurs by placing a nonwoven comprising microfibers (i.e. fibers having a titre of 0.01 to 1.0 dtex and preferably having a titre of 0.1 to 0.6 dtex) on top of a nonwoven made of skeleton fibers (i.e. fibers having a titre of more than 1 dtex), hereinbelow also called fibrous skeleton. The fiber materials are chosen such that the melting temperature of the skeleton fibers is higher than that of the microfibers. Subsequently many microjets of water are directed on to the microfibers under such high

pressure that the fibers of the microfibrous nonwoven become twisted around the coarse fibers of the fibrous skeleton. After a subsequent drying phase the nonwoven enriched with microfibers is subjected to a certain temperature by means of a heat source, e.g. a stream of hot gas directed at the nonwoven, at which temperature the fibers of the microfibrous nonwoven are melted on at least superficially - but preferably completely - after which heat treatment the skeleton fibers are bonded and stiffened in the surface region of the nonwoven.

The manufacturing method can be modified such that the microfibers are melded by means of other heat sources, such as, for example, radiant heat, from a microwave oven, by means of contact heat or by means of hot steam or another fluid. The temperature and duration of these heat sources on the nonwoven can be predetermined by the expert.

The product manufactured by this method is therefore characterized by a fibrous skeleton, whose front and/or rear surface regions comprise a continuously changing weight quota of melted on microfibrous material. The skeleton fibers, hereinbelow also called coarse fibers, have a fineness of more than 1 dtex, preferably between 6 to 17 dtex. Suitable skeleton fibers are endless spunbonded fibers as well as staple fibers. These can be made of a suitable polymer or can comprise mineral fibers, in particular glass fibers, metallic fibers or natural fibers. In advantageous embodiments this fibrous skeleton has an area weight of about 20 to 150 g/m^2. The area weight can be predetermined by the expert according to the requirements and can also have a area weight of around 800 g/m^2. Coarse fibers made of PET are used in a preferred embodiment of this fibrous skeleton.

The claimed nonwoven has been enriched in its surface region by adding melted on microfibrous material, in particular meltblown fibrous material having an average diameter of 2 - 8 µm and a fiber length of 2 - 80 mm. Depending upon the length of the fibers it has shown to be beneficial to shorten the microfibers (possibly by means of the hydroentangelement method) prior to transporting them into the fibrous skeleton. The material of these melted on microfibers is to be found mainly at the junction points of the coarse fibers, or also deposited at individual coarse fiber filaments. According to the invention, these deposits are to be found in the surface region of the nonwoven in a statistically continuously changing weight quota and decreasing in depth direction. In the preferred embodiments described, the total area weight of this melted on microfibrous material is about 5 to 50 g/m^2 (about 10-30% of the area weight of the fibrous skeleton), and the material is a Co-PET. The surface region (about 5 to 35%, max. 50% of the total thickness of the claimed nonwoven) enriched with melted on microfibrous material is still porous and substantially determines the air flow resistance of the entire nonwoven. The

nonwoven according to the invention is built up in such a manner that, following a form press step, it has an air flow resistance of 200 $Nsm^{-3} < R_t <$ 60'000 Nsm^{-3}, in particular between 800 to 35'000 Nsm^{-3}, preferably between 1'000 to 20'000 Nsm^{-3} and mainly around 1'400 Nsm^{-3}.

Furthermore, the deposition of the microfibrous material on the coarse fibers leads to a substantial stiffening of the fibrous skeleton in its surface region in such a manner that the inventive nonwoven is self supporting. In particular with a nonwoven having skeleton fibers of more than 1 dtex, hereinbelow also called coarse fibers, and by using the hydroentanglement method described above in combination with the melting process, a particularly enhanced stability and form strength can be achieved because, on the one hand, mere twisting of the coarse fibers already leads to a certain strengthening in the surface region and on the other hand, the drop-like melted on microfibrous material adheses to the coarse fibers and thereby further stiffens these when it solidifies, in particular further strengthening the junction points. The combination of both these stiffening mechanisms results in the desired bending stiffness of the inventive nonwoven, i.e. results in a particularly form strengthened and self supporting nonwoven which can be used by the automobile industry.

The pronounced elasticity and resilience of the coarse fibers in the interior of the nonwoven in combination with the continuously changing stiffness in the surface region results in an acoustically highly effective part. This part acts like an acoustic spring-mass-system whose mass is substantially replaced by a porous stiffening in its surface region. With such an acoustic system, the unavoidable onset of resonance characteristic of classic spring-mass-systems can be compensated or avoided.

However It is to be understood that the specific design of the inventive nonwoven depends upon its foreseen use. Thus, the front side of the inventive nonwoven can be open pored whilst the rear side of the same nonwoven can be impermeable to air.

It is also possible to use a microfibrous nonwoven which as been made of meltblown fibers having a varying fineness, having different melting points, or a combination of these. Further it is possible to adjust the impingement of the water microjets transporting the microfibers by regulating the pressure and duration such, that the penetration depth of the one or other type of microfiber is controlled. In this manner a nonwoven can be provided which, after being submitted to a heat treatment, has a sticky nonwoven surface comprising partially melted on microfibers, which allows another standard nonwoven or an inventive nonwoven to be

adhesed thereto. It is to be understood that the use of suitable mixtures of microfibers allows the air flow resistance in the surface region to be easily tuned.

The advantages of the present invention are immediately apparent to the expert. In particular, the combination of known manufacturing methods used in other fields allow the production of a nonwoven suitable for lining motor vehicles which has a predetermined air flow resistance and the required bending stiffness but does not have discrete layers. The possibility of obtaining a nonwoven which is suitable to be used as a motor vehicle liner, having a stiff surface region and a region integrated into this surface region for producing a predetermined air flow resistance is surprising. The nonwoven produced according to the invention is extremely thin, i.e. is also light weight and can be easily tuned, i.e. can be designed in such a manner as to have a predetermined stiffness and a selectable acoustic efficiency. It has proven to be particularly advantageous that the inventive nonwoven cannot delaminate even after long and intensive use. The removal of the risk of delamination also results in an increased durability of the inventive nonwoven. Furthermore, the present nonwoven can be made of only one type of material and still has all the properties required for a modern motor vehicle liner. Thus, the inventive nonwoven can be made into a mono-material part, allowing it to be cheaply disposed of or recycled.

For the sake of clarity hereinbelow no distinction will be made between endless filaments or fibers having a certain length and the term "fibers" shall include both. To the expert, the term "microfibers" as a rule means meltblown fibers having a titre of 0.01 to 1.0 dtex, preferably a titre of 0.1 to 0.6 dtex and typically a titre of 0.2 dtex. The coarse fibers mentioned herein should have a titre of more than 1.0 dtex and/or can also comprise natural fibers such as sisal, coir, hemp, bark, or glass fibers, metallic fibers or mineral fibers.

Further advantageous embodiments of the nonwoven according to the invention have the features of the dependent claims.

In the following, the invention shall be more closely described with the aid of an exemplary embodiment and the drawings.

Figure 1 shows a schematic view of a method for producing an inventive nonwoven;

Figure 2 shows an enlargement of the region A in Figure 1;

Figures 3a to 3d show schematic views of physical properties of an inventive nonwoven;

Figure 4 shows a schematic view of an enlarged section of an inventive nonwoven; and

Figure 5 shows a schematic view of the manufacturing process of a further development of the inventive nonwoven.

For producing an nonwoven 1 according to the invention, and as schematically shown in Figure 1, a coarse fiber nonwoven 2 is covered with a microfiber layer. This coarse nonwoven 2 preferably comprises spunbonded fibers made of PET and which have a titre of more than 1.0 dtex. This coarse fibre nonwoven acts as a fibrous skeleton and has the properties of a soft spring of an acoustic spring-mass-system and has a good restoring capability. This fibrous skeleton can have an area weight of between 20 to 800 g/m^2 and is preferably made of PET material. It is to be understood that this skeleton can also comprise natural fibers, glass fibers, metallic fibers or mineral fibers. In the present embodiment, the covered nonwoven is subjected to a so-called hydroentanglement process with which the laid-on microfiber layer 3 is transported into a surface region 4 by means of water microjets 5. The term "surface region" as used herein defines a region of the nonwoven comprising microfiber material and extending between one third and one half of the thickness of the entire nonwoven. During this process the microfibers slide along the skeleton fibers and wrap themselves around these or preferably are twisted around junction points of the fibrous skeleton. These microfibers have a titre of 0.01 to 1.0 dtex, preferably a titre of 0.1 to 0.6 dtex and typically a titre of 0.2 dtex and are preferably also made of PET or a Co-PET. This method permits the penetration depth of the microfibers to be controlled and ensures that the weight quota of these introduced microfibers is selectively continuously distributable throughout the surface region of the fibrous skeleton, and in particular in a continuously changeable manner; this means that the gradient of the weight quota of the introduced microfibrous material can be selectively adjusted. The fibrous skeleton 2 treated in this manner is subsequently subjected to a drying and heating process, and in particular is transported through a processing station in which the microfibers introduced into the surface region 4 of the fibrous skeleton 2 are melted on with the aid of hot air or some other heating mechanism 6. After passing through this processing station the shape of the microfibers 3 has changed into droplets, which join the coarse fibers together in particular in the regions of their junction or crossing points, thereby strengthening the fibrous skeleton in these regions. In this way a porous and form resistant nonwoven can be manufactured, i.e. an acoustically effective and self supporting form part can be produced such as can be used by the modern automobile industry. It is to be understood that the acoustic properties and the stiffness of the

nonwoven can be selectively influenced by variation and distribution of the fibrous materials and/or by the fineness of the fibers and/or by the quota of selected fibers.

A section A of Figure 1 is shown in Figure 2. From this Figure it is evident how the drop like melted on microfibrous material 7 is deposited at the coarse fibers 8 of the fibrous skeleton 2, resulting in a stiffening of the nonwoven in its surface region 4.

Figure 3a shows the interrelationship between the different properties of the inventive nonwoven 1. The schematically shown nonwoven 1 has three regions: a microporous surface region 4; a springy core region 19; and an air impermeable base region 10. The base region 10 and the surface region 4 are produced in an analogous manner but their melted on microfibrous material can have different weight quotas and different penetration depths.

Figure 3b shows an exemplary curve for the values of the air flow resistance R_t in dependency on the depth d of the inventive nonwoven. Characteristic values for the air flow resistance in the surface region 4 lie between 500 to 5000 Nsm^{-3}, in the core region 19 these values are at around 200 Nsm^{-3} and in the base region 10 between 200 and 10'000 or more Nsm^{-3}.

The curve shown in Figure 3c illustrates the dependency of the bending stiffness B upon the depth d by way of example. This bending stiffness depends substantially on the weight quota of melted on microfibrous material and on the density of fibers in the surface region. In this example, the gradient is smaller in the microporous surface region 4 than the gradient in the air impermeable basis region 10. In an inventive nonwoven, the values for the bending stiffness can vary between 0.005 and 10.5 Nm; in particular these values are between 0.025 to 6.0 Nm.

Figure 3d shows the density quota K of the different fibers and the melted on fibrous material. Curve a shows representative values of density for the spunbonded or coarse fibers, these fibers being present in a greater density in the surface region because of the hydroentanglement process. Curve b shows an exemplary density distribution of the melted on microfibrous material and demonstrates that its weight quota has a continuously changing course. The gradient of this fibrous material is dependent upon the duration and water pressure of the hydroentanglement process. The ratio of coarse fibers to microfibers is in the range of 3:1. Curve c shows the quota of meltblown fibers which have been introduced into the surface region of the nonwoven but have not been melted. By means of these meltblown fibers it is possible to specifically regulate the air flow resistance. These non-melted on

microfibers are in particular meltblown fibers having a titre of 0.01 to 1.0 dtex and in particular consist of a Polyester, a copolyester, a polyamide, a polypropylene or a similar synthetic material, preferably PET or Co-PET.

Figure 4 schematically shows a microscopic view of the inventive nonwoven. This Figure clearly illustrates how the porous fibrous skeleton made of coarse fibers 8 is charged with melted on 7 and non-melted on 9 microfibrous material. The weight quota of the melted on fibers present directly beneath the surface is significantly higher than in the interior of the surface region 4. The distribution of the non-melted on microfibers in this region is also clearly shown. The formation of a microporous stiffening layer in the surface region of the fibrous skeleton is essential for the inventive nonwoven.

It is to be understood that the inventive nonwoven 1 can be combined with other nonwovens of the same type so as to obtain a part having use-specific properties. Such a manufacturing process is schematically shown in Figure 5. In this process differently designed nonwovens 11, 12 are subjected to a known hydroentanglement process (Station 13) in order to obtain differing intermediate products 14, 15, 16, 17 which are piled on top of each other in a suitable manner and are bonded together by means of a known heat treatment process 18.

It is obvious to the expert that the inventive nonwoven can be provided with an air permeable decor layer or with an air and/or water impermeable foil. Particularly suitable for the decor layer are woven layers, knits, fabrics, decorative nonwovens and/or foam layers.